Microstructural Modeling of Highly Porous Nickel Electrode Materials

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ABSTRACT

Advanced fibrous electrode substrates for use in Nickel electrodes in NiMH automotive cells are being studied analytically and experimentally. These highly porous fibrous networks include nickel-coated polypropylene or graphite (AS4) fibers, or pure nickel fibers, sintered with nickel powder. The electrodes must resist failures under hundreds of charge/discharge cycles, during which networks are subjected to complex cell loads.

In the current approach, analysis has been performed on model microstructures of fused fibrous networks, and has centered on analysis of 1) microstructure, as determined by careful image analysis, 2) transport properties (electrical and thermal conductivity) of damaged and undamaged networks; 3) mechanical response and damage progression- analysis; 4) experimental verification, ranging from mechanical testing of the dry substrates, to tests of cell performance. In the current methodology, micromechanical modeling has involved loading model fibrous microstructures until fiber "struts" begin to break, and overload their neighbors. Solution for the resulting potential fields has been made separately, for damaged and undamaged networks.

Developed approaches have allowed transport to be modeled at the microstructural level. Stochastic failure analyses have been performed, using periodic unit cells comprised of fibers whose length and orientations are specified by one of several distribution functions. NiMH and NiCad batteries have provided the experimental platform for full-scale cell performance assessment, using a variety of engineered substrate materials.

This research will provide important insight into the behavior of porous materials under the particular loading conditions in batteries. Future work will include analysis of other porous component materials, of varying microstructure, used in other electrochemical applications.